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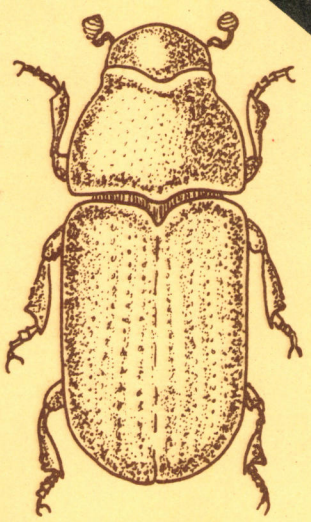
EVALUATION
Salt Damage

Crest Road
Sandia Ranger District
Cibola National Forest
New Mexico



Southwestern Region

U. S. DEPARTMENT OF AGRICULTURE

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Salt Damage

Crest Road
Sandia Ranger District
Cibola National Forest
New Mexico

Insect and Disease Control
State and Private Forestry
Southwestern Region, Forest Service, USDA
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INTRODUCTION

Treatment of highways with sodium chloride deicing salt can cause damage to roadside vegetation. Various species of conifers have been severely damaged by deicing salt in several areas of the United States (Shortle and Rich 1970, Smith 1970, and Spotts et al. 1972). Symptoms of salt damage on conifers include chlorosis or necrosis of needle tips, premature needle cast, and frequently a reduction in growth. Symptoms expression usually results from accumulation of chloride, rather than sodium toxicity (Spotts et al. 1972).

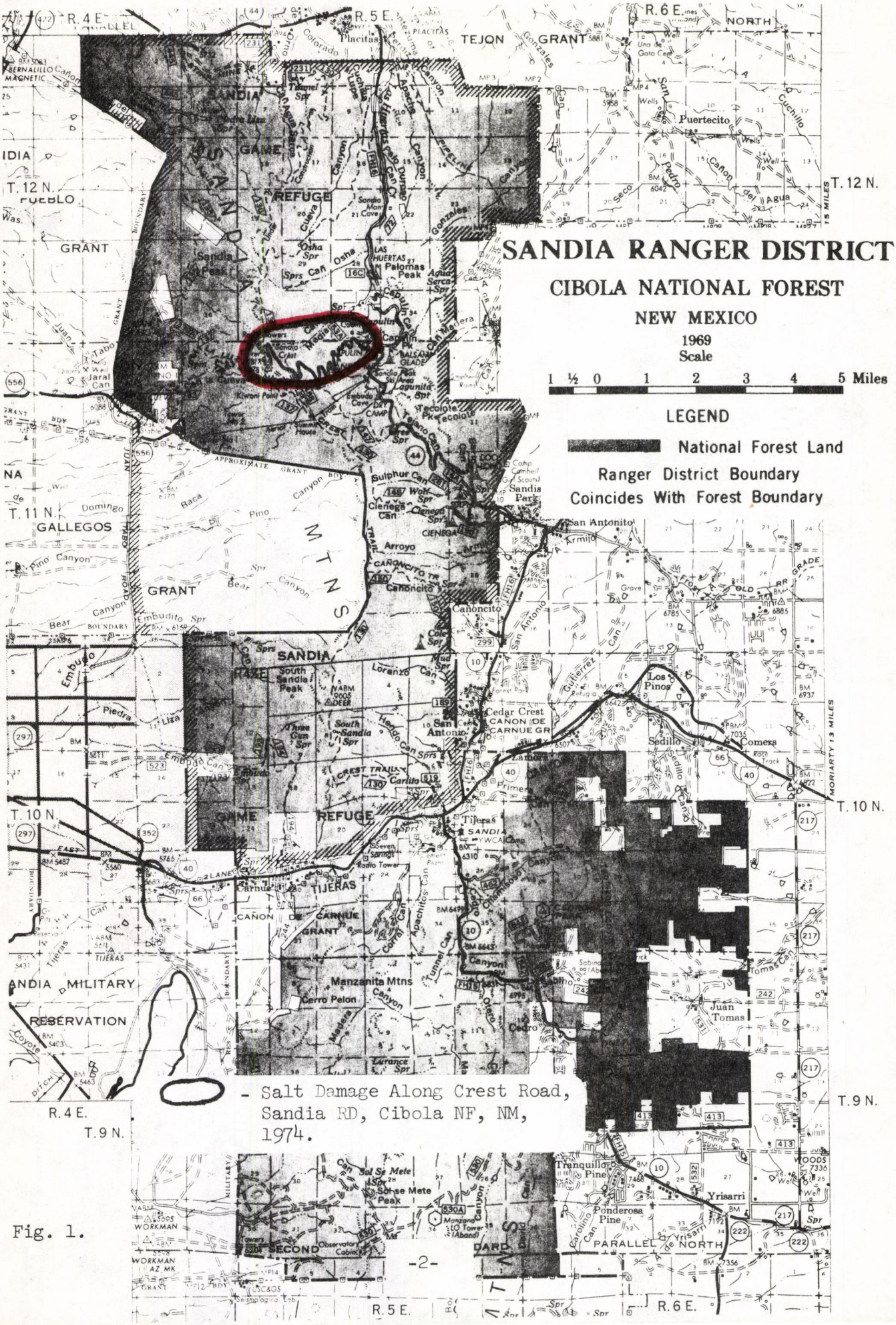
BACKGROUND

Declining white fir (Abies concolor) along the Crest Road, Sandia Ranger District, Cibola National Forest, were examined by personnel from Insect and Disease Control in December 1973 (Fig. 1). No insects or disease pathogens that could have caused the roadside decline of white fir were evident. A preliminary evaluation of the white fir decline indicated that chloride probably caused the damage (R-3 74-18). Additional study of the decline during the spring of 1974 was recommended.

Personnel from Insect and Disease Control conducted a detailed study of the white fir decline during May and June 1974. Personnel from the New Mexico Highway Department indicated that deicing salt has been applied over the entire 5.5 miles of the Crest Road each winter since 1970. Approximately 80 tons of salt per season were applied in 1970, 1971, and 1973. About 160 tons of deicing salt were used to treat the Crest Road in 1972. The first damage to conifers was noted by personnel from the Sandia Ranger District in 1972. White fir was the only coniferous species showing symptoms of damage. Damage symptoms included chlorosis and necrosis of needle tips and premature needle cast (Fig. 2). Discoloration of roadside aspen foliage was noted by District personnel during the summer of 1973; however, this was not evident at the time of this evaluation. Thus, only coniferous species were examined in 1974.

METHODS

Preliminary examination of conifers along the roadside revealed scattered individuals and groups of declining trees. White fir, subalpine fir (Abies lasiocarpa), and Engelmann spruce (Picea engelmannii) were the species having damage symptoms. Forty trees within 30 feet of the road were sampled in 10 areas along the Crest Road. Three trees were sampled at the top, middle, and bottom of the Crest Road, for a total of nine controls. Control trees were located at least 200 yards from the road. Foliage samples were



- Salt Damage Along Crest Road, Sandia RD, Cibola NF, NM, 1974.

Fig. 1.

Fig. 2.--Chloride damage to white fir.

collected from all sides of each sample tree. All trees were tagged for future reference. Chlorotic or necrotic needles were collected in preference to non-symptomatic needles on partially damaged trees. Approximately 1 pound of needles was collected from each sampled tree. Non-damaged trees adjacent to visibly damaged trees were also sampled. Data collected for each sample tree included: tree species, diameter at breast height, damage rating, distance from pavement, slope off road, and presence or absence of bark beetles. Diameter measurements were taken to the nearest tenth inch. Damage rating consisted of the following four categories:

0 = no visible damage symptoms
1 = less than 33% of the foliage chlorotic or necrotic
2 = 33-66% of the foliage chlorotic or necrotic
3 = greater than 66% foliage chlorotic or necrotic

Distance from the edge of the pavement to the sample tree was recorded to the nearest foot. Slope off the road was recorded as none, uphill, or downhill.

Foliage samples were submitted for chloride analysis to Controls for Environmental Pollution, Inc., 1925 Posina, Santa Fe, New Mexico 87501. The procedure used in determining chloride content of the foliage is as follows:

> The entire sample is dried at 105° C for at least 8 hours, weighed and placed in a large beaker. The needles are crushed with a stirring rod and leached in deionized water for at least 1 hour. The water is then filtered through glass wool, the needles rinsed several times with deionized water, and all extracts are combined and measured for volume. The chloride content of the leach water is determined with a chloride-specific-ion electrode and meter which are calibrated with sodium chloride standard solutions. The percentage of chloride in the dried needles is calculated knowing the chloride concentration in the leach water and the volume of liquid.

Sixteen soil samples were taken from the top 6 inches of soil. Four of the samples were controls collected at least 200 yards from the road; the remainder were collected at various distances from the pavement in five of the foliage sampling areas. Chloride content was determined in milliequivalents per liter of soil extract at the Soil Testing Laboratory, Cooperative Extension Service, New Mexico State University, Las Cruces, New Mexico 88001.

In total, 16 increment cores were taken from sample trees in three of the damage areas. Cores were taken from trees in each damage category. To determine if a reduction in growth had occurred, annual rings from the past 4 years were measured and compared with an average growth ring measurement for the preceding 10-year period.

RESULTS AND DISCUSSION

In total, 49 trees were sampled in the evaluation. Four of the sampled white fir were heavily infested with bark beetles, which apparently was the principal cause of their death. Thus, information pertaining to these trees is not included in the data analysis. Damage symptoms, including chlorotic and necrotic needle tips, as well as premature needle cast, occurred on all species of affected trees.

The following tabulation indicates the disposition of the remaining 45 trees relative to location, damage, and species.

Species	Roadside trees		Controls
	Damaged	Not damaged	
White fir	12	7	9
Subalpine fir	10	3	0
Engelmann spruce	4	0	0

A comparison of the mean and range of diameters for roadside sample trees indicates that damaged trees are of larger diameter than non-damaged (Table 1). There was no apparent relationship between tree diameter and either chloride content of foliage or damage rating.

Comparison of foliage chloride content with damage rating of roadside trees provided variable results, although there was a trend toward higher chloride content with higher damage ratings (Table 2). In comparing mean percent chloride in roadside trees, chloride content was higher in damaged trees than in non-damaged trees (Table 3).

All damaged roadside trees were within 25 feet of the pavement. There was no definite relationship between distance from the road and chloride content (Table 4). However, as distance from the pavement increased past 15 feet, the number of damaged trees decreased for all species.

Five of the sampled trees, excluding controls, were located uphill from the road. Damage symptoms were evident on three of the five trees; however, they were infested with bark beetles. The remaining two trees, located uphill from the road, showed no symptoms of damage. The slope off the road was downhill for all trees that had damage symptoms.

Table 1.--Mean and range of diameter of roadside trees for damaged classes and non-damaged category, by species.

	Damaged		Non-damaged	
	Mean d.b.h.	Range	Mean d.b.h.	Range
White fir	8.03	1.0-16.4	5.83	2.2-9.9
Subalpine fir	6.48	2.7-12.2	4.10	3.4-4.9
Engelmann spruce	5.05	2.9- 7.0	--	--
All species	6.98	1.0-16.4	5.31	2.2-9.9

Table 2.--Mean percent chloride for roadside trees by damage categories.

Damage rating	Mean % Cl WF	Range	Mean % Cl SF	Range	Mean % Cl ES	Range	Mean % Cl AS	Range
0	.08	.03- .14	.08	.07-.09	--	--	.08	.03- .14
1	.23	.10- .32	.06	.03-.08	.14	--	.14	.03- .32
2	1.18	1.14-1.21	.25	.05-.45	.14	--	.60	.05-1.21
3	.77	.31-1.91	.20	.07-.28	.11	.06-.16	.49	.06-1.91

Table 3.--Mean percent chloride for damaged and non-damaged roadside trees and for controls.

Species	Mean % Cl damaged	No. trees	Mean % Cl non-damaged	No. trees	Mean % Cl controls	No. trees
White fir	.71	12	.08	7	.20	9
Subalpine fir	.17	10	.08	3		
Engelmann spruce	.13	4	--	0		
All species	.42	26	.08	10		

Table 4.--Mean percent chloride by distance categories for the 26 roadside trees with damage.

Distance (ft)	Mean % Cl WF	No. trees	Mean % Cl SF	No. trees	Mean % Cl ES	No. trees	Mean % Cl AS	No. trees
1-5	--	0	.25	3	.06	1	.21	4
6-10	.50	5	.13	5	.15	3	.28	13
11-15	.95	7	--	0	--	0	.96	7
16-20	--	0	--	0	--	0	--	0
21-25	--	0	.12	2	--	0	.12	2

WF = white fir
SF = subalpine fir
ES = Engelmann spruce
AS = all species

The mean chloride content of controls was .20 percent. All but two of the control trees had very low chloride content (less than .13%). The two control trees having relatively high chloride content were located at the bottom of the Crest Road. Although they were at least 200 yards from the road, enough runoff could have come down the mountain to influence the chloride content of the foliage.

Chloride content of the damaged foliage samples compares favorably with data from a study of Picea abies (Dragsted 1973). Damage to foliage occurred at chloride concentrations similar to those noted by Dragsted (1973). Chloride content of foliage was somewhat higher in this evaluation than in the preliminary evaluation of white fir decline along the Crest Road (R-3 74-18). However, the difference between chloride content in roadside trees with damage versus those with no damage is equally, if not more, prominent in this evaluation.

The difference between the mean percent chloride in foliage of healthy and damaged white fir was significant at the 95 percent level ($t = 3.15$, d.f. = 17), while it was not significant in subalpine fir ($t = 1.13$, d.f. = 11). In comparing damaged and non-damaged trees of all species, the means were significantly different at the 95 percent level ($t = 2.43$, d.f. = 34).

Results of growth measurements derived from increment core samples were inconclusive. Of the ten trees sampled with a damage rating of 3, four had greater growth, four had less growth, and two remained constant. The remaining six core samples from trees rated 0, 1, or 2 were about evenly divided between greater and less growth. Thus, no indication was provided relative to growth reduction due to chloride injury.

Soil analysis results indicated higher levels of chloride in trees near the pavement. Chloride is easily leached into lower horizons. Since the samples were taken from the surface soil layer, the relative concentration of chloride in the soil may be somewhat low. However, no information on soil chloride contents in mixed conifer stands is presently available for comparison. The highest soil chloride levels occurred in the same areas as the highest foliage chloride levels.

Soil samples from roadside to 20 feet beyond roadside ranged from 11 ppm to 256 ppm chloride, with a mean of 86 ppm. The control samples ranged from 4 to 37 ppm chloride, with a mean of about 16 ppm. The soil sample data from this evaluation compare favorably with results of soil salinity studies in ponderosa pine (Spotts ea al. 1972). Damage to foliage corresponded with high soil salinity levels at concentrations similar to those for ponderosa pine determined by Spotts et al. (1972).

CONCLUSIONS

Results of this study strongly indicate that damage to white fir along the Crest Road is due to chloride toxicity. Damage to roadside subalpine fir and Engelmann spruce may be due to chloride toxicity; however, data for these species are inconclusive. The mean percent chloride in foliage samples varied with the three species, thus levels of chloride necessary to damage foliage are difficult to derive.

Future treatment of the Crest Road with deicing salt will result in continued damage to white fir within 25 feet of the pavement. Subalpine fir and Engelmann spruce within 25 feet of the pavement may also be damaged by future treatment of the Crest Road with deicing salt. Various alternatives to the present deicing salt treatment of the Crest Road should be examined. Tagged trees along the Crest Road will be examined annually for several years in order to monitor chloride levels and continued damage to roadside trees.

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